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ABSTRACT

A study of the responses made to problems selected from Raven's Progressive Matrices showed differences in the kinds of errors typically made by eighteen-year-old students. Nine problems were used and the 68 subjects were told to draw their answers on the answer sheets. There were two trials per puzzle. A classification system, devised for errors, included categories of failure to understand the principle underlying the puzzle and errors due to incomplete application of the correct principle. Thirteen-year-olds' errors indicated a failure to understand the principle underlying the puzzles. Eighteen-year-olds' errors indicated that they understood the principle but applied it incompletely. These results supported the contention that qualitative differences between younger and older adolescents can be inferred from their nonverbal performance alone. In addition, results were consistent with previous findings that older adolescents performed at higher levels than younger adolescents on formal operational problems. (Author/CTM)

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Qualitative Differences between Thirteen-and Eighteen-Year-Olds on a Nonverbal Problem-Solving Task

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Running head: Qualitative Differences

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Abstract

In drawing solutions to puzzles, thirteen- and eighteen-year-olds make different types of errors ($F = 4.08$, $p < .001$). Thirteen-year-olds' errors indicate a failure to understand the principle underlying the puzzles. Eighteen-year-olds' errors indicate that they understand the principle but that they apply it incompletely. These results support the contention that qualitative differences between younger and older adolescents can be inferred from their nonverbal performance alone. In addition, they are consistent with previous findings that older adolescents perform at higher levels than younger adolescents on formal operational problems.

Qualitative Differences between Thirteen-and Eighteen-Year-Olds on a Nonverbal Problem-Solving Task

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Boston University

The purpose of the research project on which I am reporting today was to demonstrate that qualitative differences in adolescents' problem solving can be inferred from their nonverbal performance alone. Previous research on problem solving during adolescence has been restricted, in large part, to studies of formal operational thought (Neimark, 1975). Among other things, these studies document a tendency for older adolescents to perform at more advanced levels of formal operational thought than younger adolescents (Kuhn, Langer, Kohlberg, & Haan, 1977; Martorano, 1973; Tomlinson-Keasey, 1972).

One drawback of these studies is that subjects' stage classifications depend not only on their performance but also on their verbal justifications of that performance. While the use of verbal justifications is essential from the perspective of Piagetian theory, it does not adequately reveal the competence of adolescents who are not verbally facile (e.g., deaf or aphasic adolescents; see Furth, 1971; Furth & Youniss, 1969). What is necessary to reveal the competence of these adolescents is a task and classification system which are totally dependent on nonverbal performance.

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I have designed such a task and classification system. To construct the task, I selected nine puzzles from Raven's Standard and Advanced Progressive Matrices which I thought would reveal qualitative differences in adolescent thought. As shown in Figure 1, picture A, three of the puzzles are essentially identical to the two-dimensional multiplicative classification tasks which can be solved by concrete operational children (Caruso & Resnick, 1972; Inhelder & Piaget, 1964). The remaining six puzzles each involve a level of complexity beyond that inherent in concrete operational classification. Two of the puzzles have an added dimension; two have an added dimension and are more complex figurally (see Figure 1, picture 3); one is more complex logically (see Figure 1, picture C); and, one is more complex logically and figurally (see Figure 1, picture D). As you can see from pictures A through D, solving all of these puzzles depends upon grasping the principle that they can be analyzed into dimensions (e.g., figure and background in picture A) and attributes, and that those attributes whose product or partial product is not already represented in the eight filled cells are to be multiplied together to generate the correct solution. In other words, in order for a solution to be correct, it must contain no attributes which have already appeared together in the matrix.

The classification system consists of a set of categories and subcategories into which subjects' errors can be classified. Of interest here are the incorrect solutions which indicate a complete failure to understand the principle underlying the puzzles and those which indicate a correct understanding of the principle but an incomplete application

of it.

Repetitions are errors which are attributable to a complete failure to understand the principle. As you can see in Figure 2, repetitions duplicate one of the pictures in the puzzle that has no attribute in common with the correct picture.

Wrong principle errors are also attributable to a complete failure to understand the principle underlying the puzzle. There are three categories of wrong principle errors. Same errors contain combinations of incorrect attributes from dimensions depicted in the puzzle. The attributes are incorrect because their product or partial product is already pictured in the puzzle. (For example, in Figure 2 the same wrong principle error on the left contains two attributes--shape and length of arms-- whose partial product is represented in puzzle B. In puzzle B, the zig-zag shape with its arms shorter than the crossbar appears in the diagonal orientation.) New errors involve the introduction of attributes belonging to dimensions not depicted in the puzzle. Within-dimension errors contain an incorrect recombination of components within one dimension and do not contain the correct attribute from the other dimension. For example, the two within-dimension errors in Figure 2 result from combining the components $\overline{P}$ and $\overline{Q}$, that is, an open figure with a half figure, with incorrect attributes from the dimension, shape.

Incomplete correlate errors indicate a correct understanding but an incomplete application of the principle underlying the puzzle. They indicate a correct understanding in that they have one or more

attributes in common with the correct solution. They indicate an incomplete application in that they have one or more attributes which differ from the correct solution. Examples of incomplete correlate errors are pictured in Figure 3. Adjacent and nonadjacent errors are incomplete correlate errors which duplicate pictures adjacent or not adjacent, respectively, to the correct answer. Within dimension errors are incomplete correlate errors which involve a recombination of the components within one dimension. Original errors are incomplete correlate errors which do not duplicate any picture in the puzzle. That is, they contain one or more correct attributes and one or more incorrect attributes, all of which are combined to produce an answer not already present in the puzzle. Thus, original incomplete correlate errors are the most sophisticated form of error since they indicate a correct understanding of the principle and since they do not duplicate any pictures in the puzzle.

Since repetitions and adjacent and nonadjacent incomplete correlate errors all duplicate pictures in the puzzles, we also classified these three types of errors as duplications.

Because the research on formal operational thought indicates that older adolescents perform at higher levels than younger adolescents, I hypothesized that we would find similar differences with our nonverbal puzzles. In particular, I hypothesized that younger and older adolescents would make qualitatively similar errors on the three concrete operational problems, since both groups would have long since reached

the state of concrete operations, but that on the six more complex problems there would be an interaction between age and error category, with younger adolescents making more wrong principle and duplication errors and older adolescents making more original incomplete correlate errors.

Method

Thirty-four eighth graders and 34 college freshmen served as subjects. Their mean ages were 13; 6 months and 18; 10 months, respectively. Each subject was given a booklet containing the puzzles and an answer sheet. Subjects were told to figure out the missing ninth picture by scanning the eight pictures present. They drew their answers on the answer sheets. There were two trials per puzzle. Thus, there were two drawings per puzzle, eighteen drawings per subject.

Results

Subjects' drawings were scored for each trial. Any subject who responded with a blank or unfinished drawing was deleted from the analysis for that trial. Thirteen eighteen-year-olds and three thirteen-year-olds were deleted from trial one. Seven eighteen-year-olds and one thirteen-year-old were deleted from trial two. Two raters independently scored 17 protocols randomly selected from these for each age group. Interrater reliability for the error categories and subcategories on undeleted trials was 87% and 93%, respectively, for thirteen-year-olds and 89% and 98%, respectively, for the eighteen-year-olds.

As expected, there were no significant differences between age groups on the concrete operational problems. An age x trial analysis

of variance of the total number of errors made by each subject also revealed no significant differences between age groups.

The results of an age x trial and error category repeated measures ANOVA are depicted in Table 1. The main effect for trial is due to a decrease in errors from trial 1 to trial 2. The main effect for category is due, for the most part, to there being significantly more errors made in the original incomplete correlate category than in any other category and to there being significantly more errors made in the same wrong principle category than in four of the other categories.

The predicted significant age x category interaction is graphed in Figure 4. Duncan's test for multiple comparisons revealed that thirteen-year-olds made significantly more same wrong principle errors and eighteen-year-olds made significantly more original incomplete correlate errors. In order to further examine repetitions and adjacent and nonadjacent incomplete correlate errors, we summed each subjects' error frequencies for these categories to arrive at a duplication error frequency. An age x trial x category ANOVA did reveal a significant age x error category interaction. Duncan's test for multiple comparisons revealed that eighteen-year-olds made significantly more duplication errors than thirteen-year-olds.

Discussion

What can we conclude from these results? First, qualitative differences between adolescents can be inferred from their nonverbal performance alone, specifically from their drawing errors. Second, we

confirmed two of our hypotheses. Thirteen-year-olds do make significantly more wrong principle errors, specifically in the same wrong principle subcategory. This means that when thirteen-year-olds err, they do so by drawing solutions which are combinations of attributes, the products or partial products of which are already present in the matrix. They do not understand that the correct solution must consist of those attributes which have not already appeared together in the puzzle. Eighteen-year-olds do make significantly more original incomplete correlate errors. This means that when they err, they do so by incompletely applying the principle of combining those attributes which have not already appeared together. Thus, eighteen-year-olds make errors which indicate that they have a greater understanding than thirteen-year-olds of the principle underlying the puzzles. This result is consistent with previous findings that older adolescents perform at higher levels on formal operational problems than younger adolescents (e.g., Martorano, 1973).

Finally, we found that eighteen-year-olds also make what appears to be a very unsophisticated error; when they err, they sometimes draw pictures which are already present in the puzzle. Since many of these errors are incomplete correlate errors, perhaps when they do not know the answer, eighteen-year-olds prefer copying a partially correct answer over drawing a totally incorrect one. Currently, I am conducting another research project which should determine whether this preference is the reason why eighteen-year-old adolescents make this type of error.

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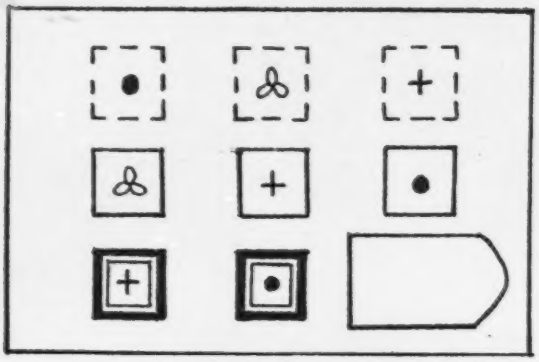
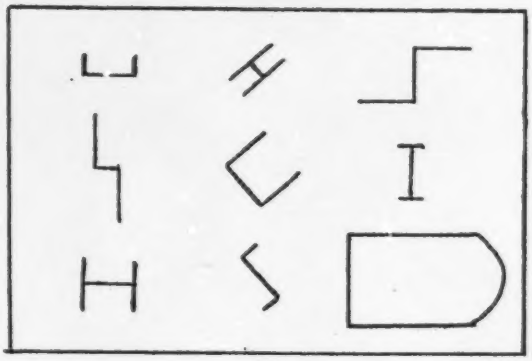


A

Solution:

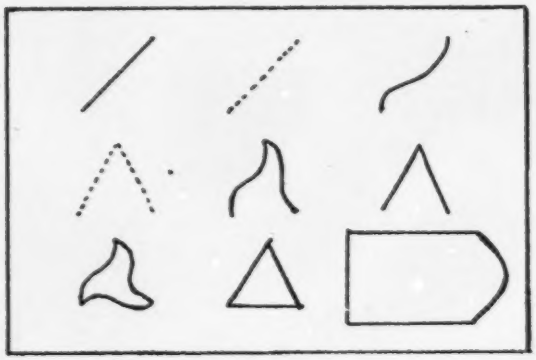
Logical Structure: A x B



B

Solution:

Logical Structure: A x B x C

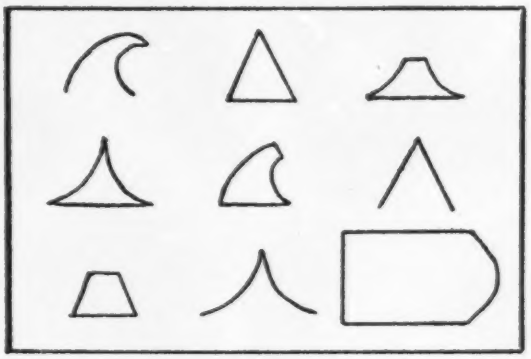


C

Solution:

Logical Structure: A x PQ

[where PQ takes on the values, PQ = dashed·straight, PQ = solid·straight, PQ = solid·curved]



D

Solution:

Logical Structure: A x PQ

[where PQ takes on the values, PQ = closed·whole, $P\bar{Q}$ = closed·half, $\bar{P}Q$ = open·whole]

Figure 1: Examples of puzzles. A is essentially identical to concrete operational matrix classification tasks. B contains an added dimension and greater figural complexity. C involves greater logical complexity. D contains both greater logical and greater figural complexity. Drawings adapted from Raven's Standard and Advanced Progressive Matrices (Raven, 1958, 1962).

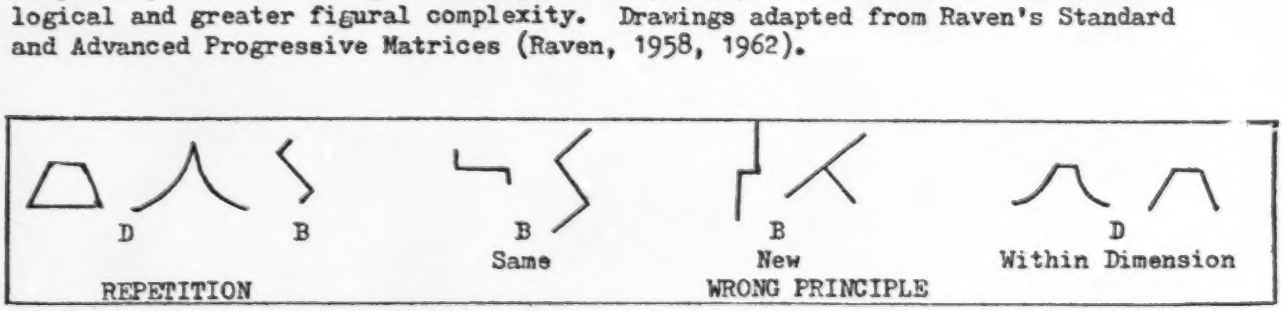


Figure 2: Examples of Repetition and Wrong Principle errors on Puzzles B and D.

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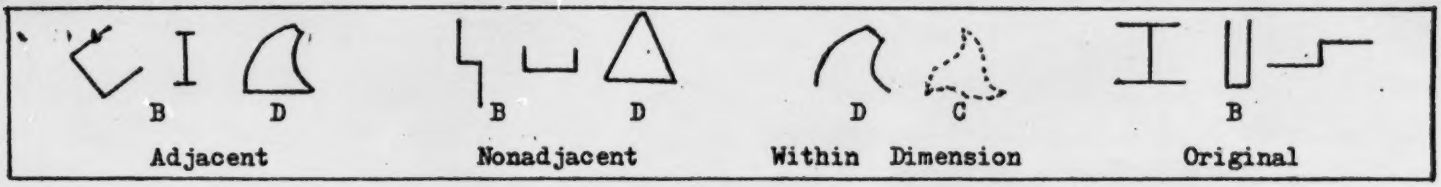

Figure 3: Examples of Incomplete Correlate errors on puzzles B, C, D.

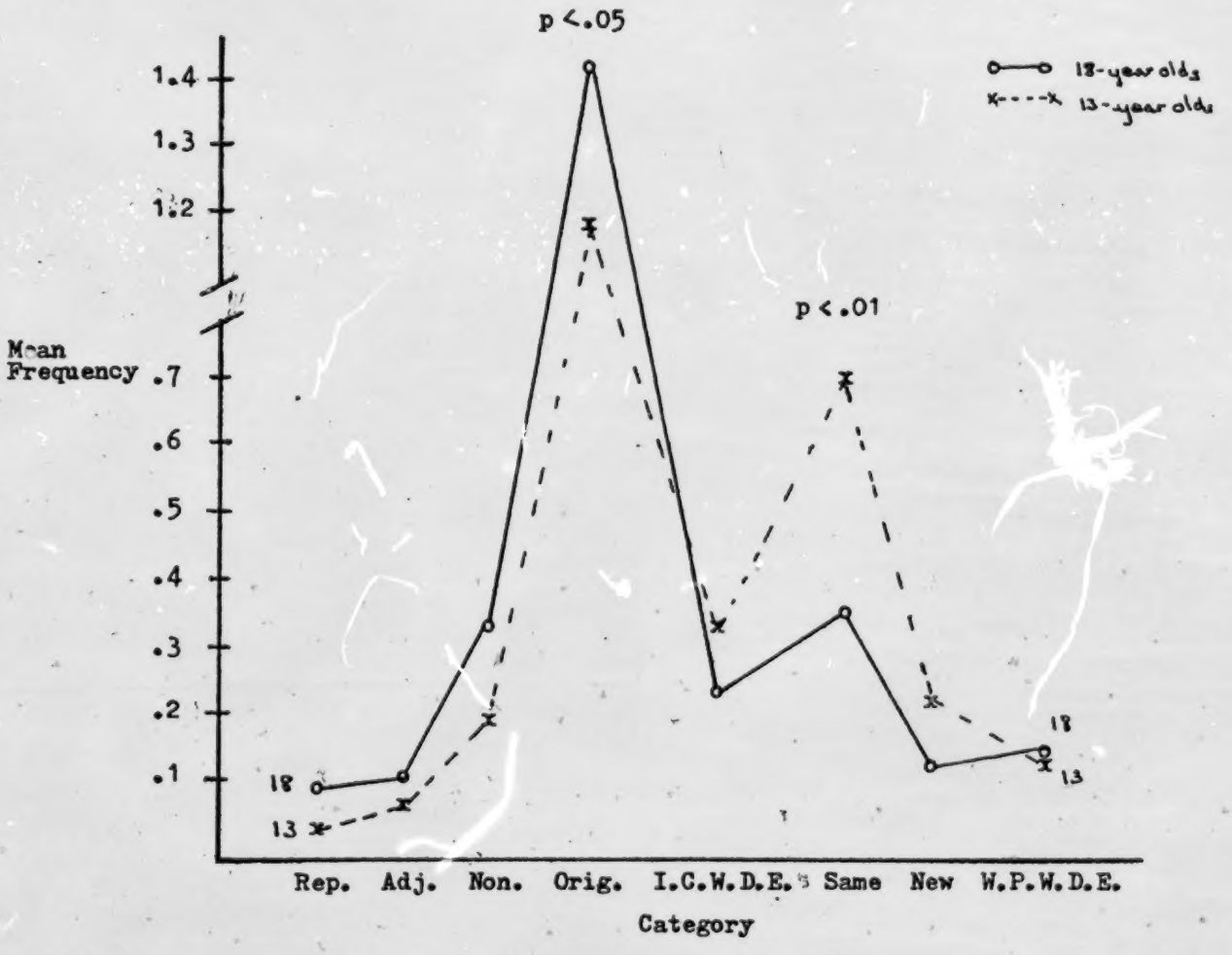

Figure 4: Age x Error Category Interaction.

Between Subjects		
Source	F	p
Age	0.00	<.982
Trial	21.38	<.001
Age x Trial	2.59	<.110

Within Subjects		
Source	F	p
Category	84.74	<.001
Age x Category	4.08	<.001
Trial x Category	1.89	<.068
Age x Trial x Category	0.22	<.981

Table 1: Results of Age x Trial x Error Category ANOVA.

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